Section 2

MINE WASTE CHARACTERISTICS

ABANDONED URANIUM MINE WASTE CHARACTERISTICS

Two important waste characteristics, the location and the types of AUM features (e.g., portals, shafts, rim strips, prospects and waste piles), have been presented in Section 1 - Mining History and Mine Site Information. Another key characteristic of waste is the estimated quantity of potential wastes associated with the mine features. As part of the planning and reclamation process, volumes of uranium mine waste piles were estimated by the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP).

Further characterization of AUM waste requires analytical sampling data. These sampling data should be designed to identify hazardous substances at the AUM sites and to determine the presence or absence of these hazardous substances in environmental media and at targets. This requires a sufficient number of samples, of sufficient quality, to show that any substances found are above background levels and are a result of activities at the AUM sites (EPA, 1991 - S01230301).

This section presents existing sampling and survey data that have been collected on the Navajo Nation, including radiation surveys, field surveys and samples, and reclamation data. These data must be examined carefully with respect to their suitability for drawing conclusions about hazardous substance releases and target exposures. While these data may provide useful insights about the types, levels, and areal distribution of hazardous substances, there are also limitations that should be considered (EPA, 1991 - S01230301):

- Previous sampling efforts may not have been conducted for purposes that are compatible with site assessment objectives.
- Previous sampling may not have been extensive enough to fully characterize the site and the possibility of a release.
- Previous sampling may be limited to one-time sampling events (e.g., water samples).
- Laboratory protocols and standards may not be known.
- Conditions may have changed since the site was last sampled/surveyed. This is a key limitation since most of the AUM sites have been reclaimed since the data samples/surveys were conducted.
- There are inaccessible mine waste piles that were too difficult and hazardous to reclaim or to collect data.

RADIATION SURVEYS

NAUM AERIAL RADIATION SURVEYS

Aerial radiation surveys were flown over the Navajo Nation during October 1994 through October 1999, and covered areas where there was known uranium mining activities. The surveys were conducted by the U.S. Department of Energy's (DOE) Remote Sensing Laboratory (RSL) to assist with locating and characterizing AUMs. The surveys were flown using a helicopter-based acquisition platform equipped with 2 x 4 x 16 inch sodium iodide (NaI[Tl]) scintillation detectors. Aircraft position was established using a real-time differential global positioning system (GPS) and a radar altimeter.

The surveys were flown at a nominal altitude of 150 feet above the terrain, resulting in a footprint of about 300 feet, and a line spacing of 300 feet. Radiation sensor measurements were integrated and recorded at one-second intervals. Each measurement provided an average radiation level for the entire ground sample area (i.e., the 300 feet diameter footprint under the helicopter as shown in Figure 1). This means the data does not pinpoint the radiation levels within the ground sample area. For each ground sample area, the radiation source could be evenly distributed or it could be made up of a combination of radiation sources, such as a higher-level mine waste debris pile placed on soil that had lower regional background radiation levels. Obtaining finer detail measurements for individual radiation sources requires additional ground-based measurements.

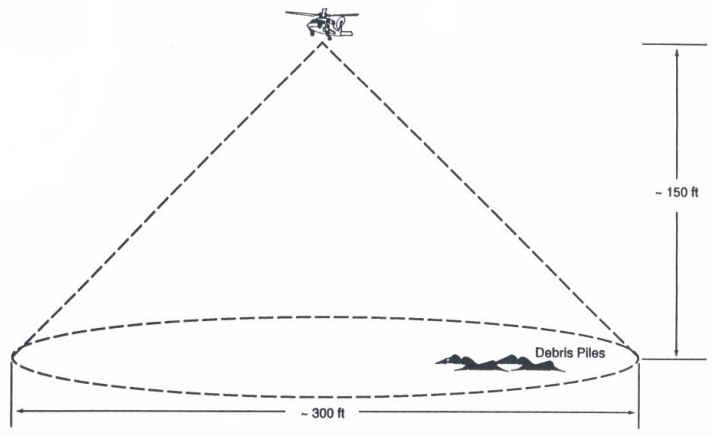


Figure 1. Aerial Radiation Survey Footprint Diagram.

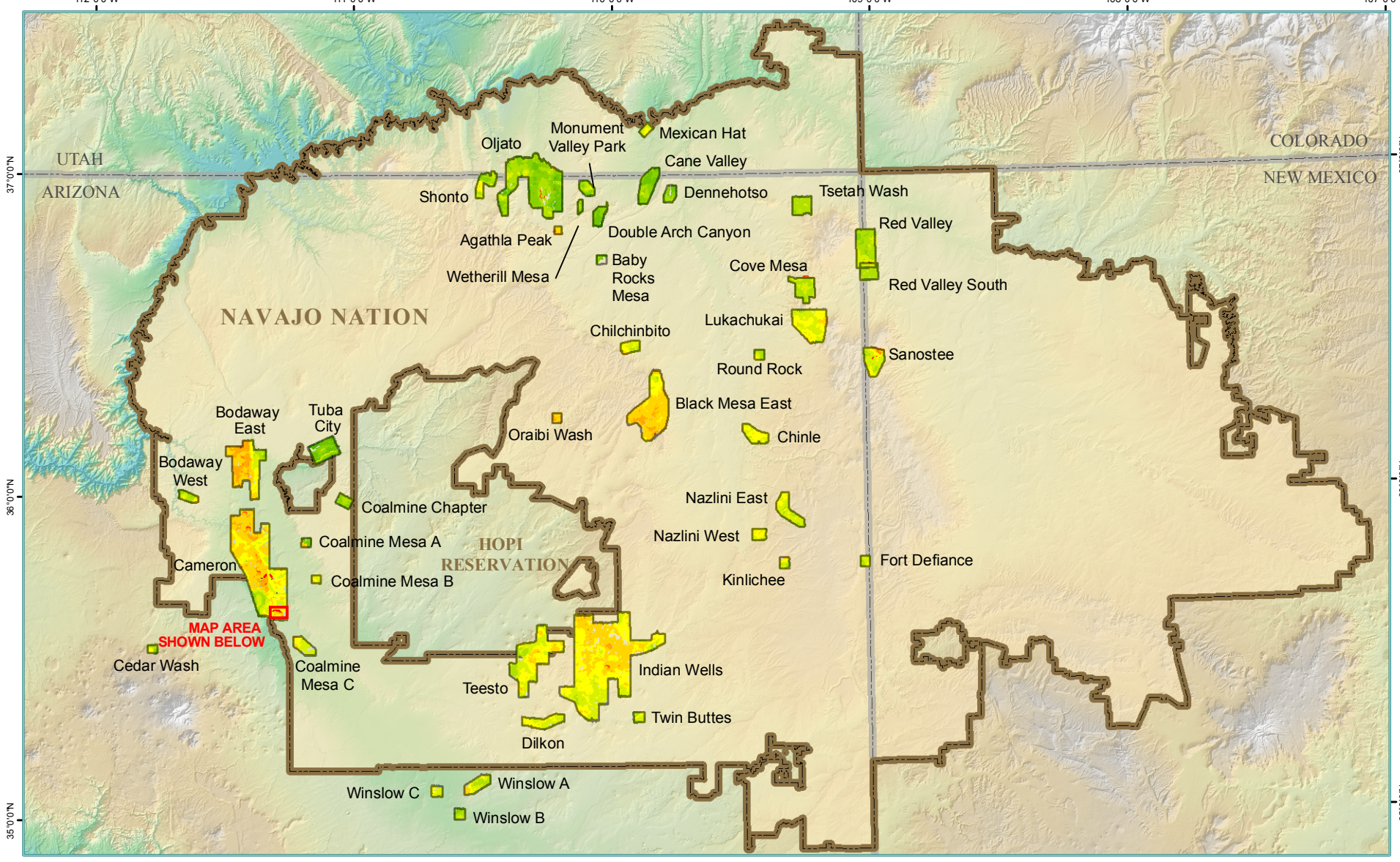
Aerial radiation surveys were flown over forty-one (41) uranium mining areas on the Navajo Nation (Figure 2). Aerial radiation surveys were not conducted over the Eastern AUM Region. A spreadsheet with summaries of the survey parameters for all areas is provided on the GIS Data DVD (DB/Radiation/NAUM_Radsurveys.xls).

Gross count and excess Bismuth-214 data were derived from the measured gamma spectral information. Gross count measures total terrestrial gamma activity, without considering its source, much like a Geiger counter. Aerial gross count data documents the wide range of radioactivity present, even in areas not associated with uranium mining activities. The gross count radiation contours are shown in Figure 2 for the entire Navajo Nation.

Bismuth-214 radiation is associated with the presence of uranium, making it a good indicator of old mines and mining related activities. The Bismuth-214 response, rather than a uranium response, is used because its unique photo peak can be readily distinguished from other radiation. The Bismuth-214 radiation polygons are shown in Figure 2 for an area in the Western AUM Region. These aerial radiation contours were used as an aid in locating and defining the surface extents of AUMs, which are also shown on Figure 2.

These GIS datasets are provided on the GIS Data DVD (DB/Radiation). Aerial radiation survey boundaries (NN_Flight_Areas.shp) and radiation contour data files were converted to GIS-compatible digital files by the DOE RSL for gross count (NN_Gross_Count_Contours.shp) and excess Bismuth-214 (NN_Excess_Bi214_Contours.shp). Additional processing was performed under the NAUM Project to convert the vector contours to polygons (NN_Gross_Count_Polys.shp and NN_Excess_Bi214.shp).

For a more comprehensive explanation of the acquisition and processing methods used for the aerial radiation measurements, a report was developed by the DOE's RSL titled "An Aerial Radiological Survey of Abandoned Uranium Mines in the Navajo Nation." (Hendricks, 2001 - S03310309). Two other aerial radiation surveys were conducted by the DOE RSL on the Navajo Nation for the Shiprock, New Mexico Uranium Mill Tailings Site (Jobst, 1981 - S10290208), and the Rio Puerco River downstream from the Church Rock Uranium Tailings Spill (Burson, 1979 - S10280211). GIS data were not provided, but scanned versions of the reports are provided on the References DVD. These surveys were flown to provide information to help guide the planning of ground-based surveys in the vicinity of the AUM sites and to evaluate the effectiveness of any cleanup efforts.



AERIAL RADIATION SURVEY AREAS AND GROSS COUNT RADIATION CONTOURS

Survey areas and gross count aerial radiation contour data are from the U.S. DOE Remote Sensing Laboratory Aerial Measuring System.

Filenames: DB/Radiation/NN_Flight_Areas.shp
DB/Radiation/NN_Gross_Count_Contours.shp

N W E S

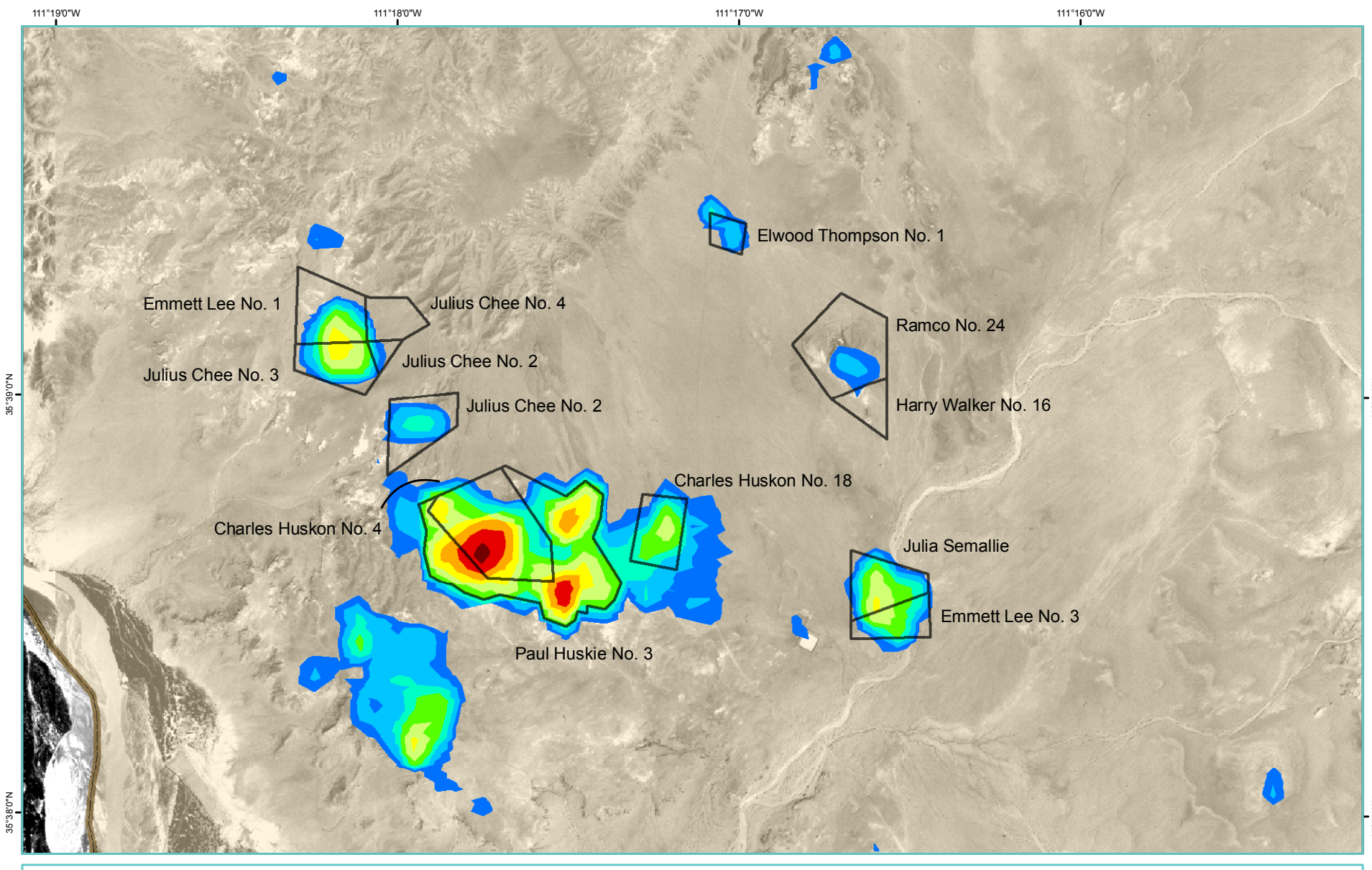
0 50 Miles

Map Scale 1:1,900,000

Aerial Survey Boundary

Radiation Contours - Units in µR/hr.

2	9
3	12
4	16
5	24
6	37
7	60



EXCESS BISMUTH 214 RADIATION DATA SOUTH AREA OF CAMERON SURVEY AREA

Excess Bismuth-214 aerial radiation data are from the U.S. DOE Remote Sensing Laboratory Aerial Measuring System.

Filename: DB/Radiation/NN_Excess_Bi214_Poly.shp

N W E S

0 0.5 Miles

Map Scale 1:24,000

Abandoned Uranium Mine

Estimated exposure rate from excess Bismuth-214 (excess µR/hr)

2.4 to 3.5	16.2 to 23.6
3.5 to 5.2	23.6 to 34.9
5.2 to 7.4	34.9 to 52.4
7.4 to 10.9	>52.5
10.9 to 16.2	

Figure 2. NAUM Project Aerial Radiation Survey Data.

RADIATION SURVEYS (continued)

NATIONAL URANIUM RESOURCE EVALUATION (NURE) AERIAL GAMMA RAY SURVEYS

One of the earliest uranium characterization programs conducted on the Navajo Nation was the National Uranium Resource Evaluation (NURE) program. NURE was initiated by the Atomic Energy Commission (AEC) in 1973 with a primary goal of identifying uranium resources in the United States. From 1974 to 1980, the NURE program systematically evaluated uranium resources of the United States by conducting airborne radiometric and magnetic surveys and by collecting hydrogeochemical and stream sediment samples (Smith, 2001 - S07250302). Aerial gamma-ray data can be used to quantify and describe the radioactivity of rocks and soils. The majority of the gamma-ray signal is derived from the upper 20-25 cm of surficial materials. A gamma-ray detector is mounted in an aircraft and flown at relatively low altitudes. Aerial gamma-ray surveys measure the flux of gamma rays emitted as a result of the radioactive decay of the naturally occurring radioactive elements K-40 (potassium), U-238 (uranium), and Th-232 (thorium). Equivalent uranium (eU) is calculated from the counts received by a gamma-ray detector in the energy window corresponding to Bismuth-214.

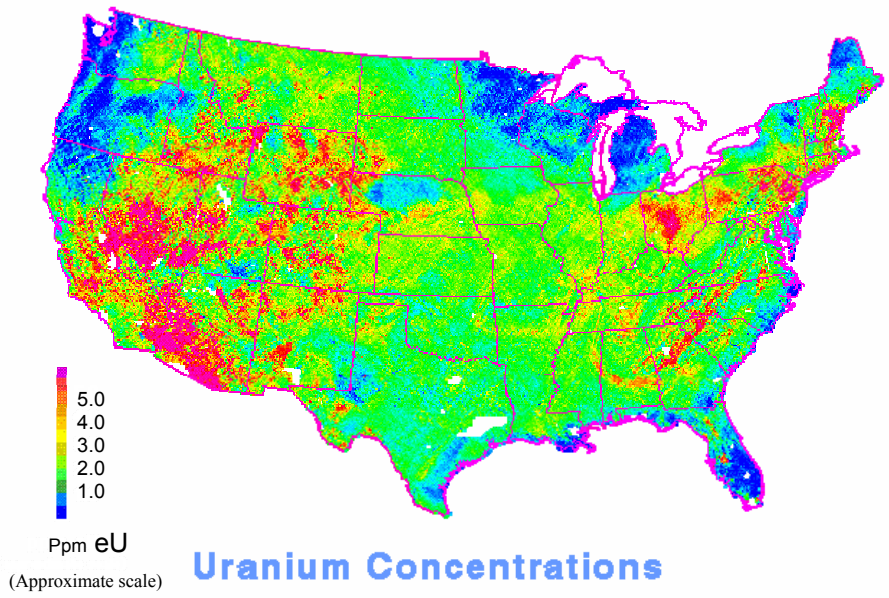


Figure 3 shows an image of the equivalent uranium for the Conterminous United States. This image was generated from NURE aerial gamma-ray data presented in United States Geological Survey Digital Data Series DDS-9, "National Geophysical Data Grids: Gamma-Ray, Magnetic, and Topographic Data for the Conterminous United States," by J.D. Phillips, J. S. Duval, and R. A. Ambrosiak, 1993. Data can be requested from the USGS at *http://energy.cr.usgs.gov/radon/orderinfo.html.*

Figure 3. Equivalent Uranium Map for the Conterminous United States

CHURCH ROCK GAMMA SCAN

In October 2003, EPA's Radiation and Indoor Environment's National Laboratory conducted a truck-mounted gamma radiation scan along transportation corridors in the Church Rock area (Shura, 2003 - S07120501). The scan chart (graph) and corresponding image shown in Figure 4 can be used together to locate the anomalous areas.

The graph shows the counts per second (Y axis) and channel number (X axis) for each second of acquired gamma flux. The green, yellow, and red coloring represents a level of the gamma rate every second as the scanner van traveled about 5 miles per hour along the scan route.

The green represents the average (plus 2 standard deviations) or lower gamma rate of the area background in counts per second. The red (average plus 7 standard deviations) represents an anomaly compared to the background rate. This anomaly may be NORM (Naturally Occurring Radioactive Material) which has a higher flux rate in dense materials such as concrete, rocks and soils in direct line of sight of the scanner van's collimated detector. Or it might be an indication of the elevated gamma flux from mining activity or similar activities or both. NORM is generally easily determined by visual examination, health physics hand held instrument surveys or laboratory analysis. The scanner van is just one tool used in an area characterization.

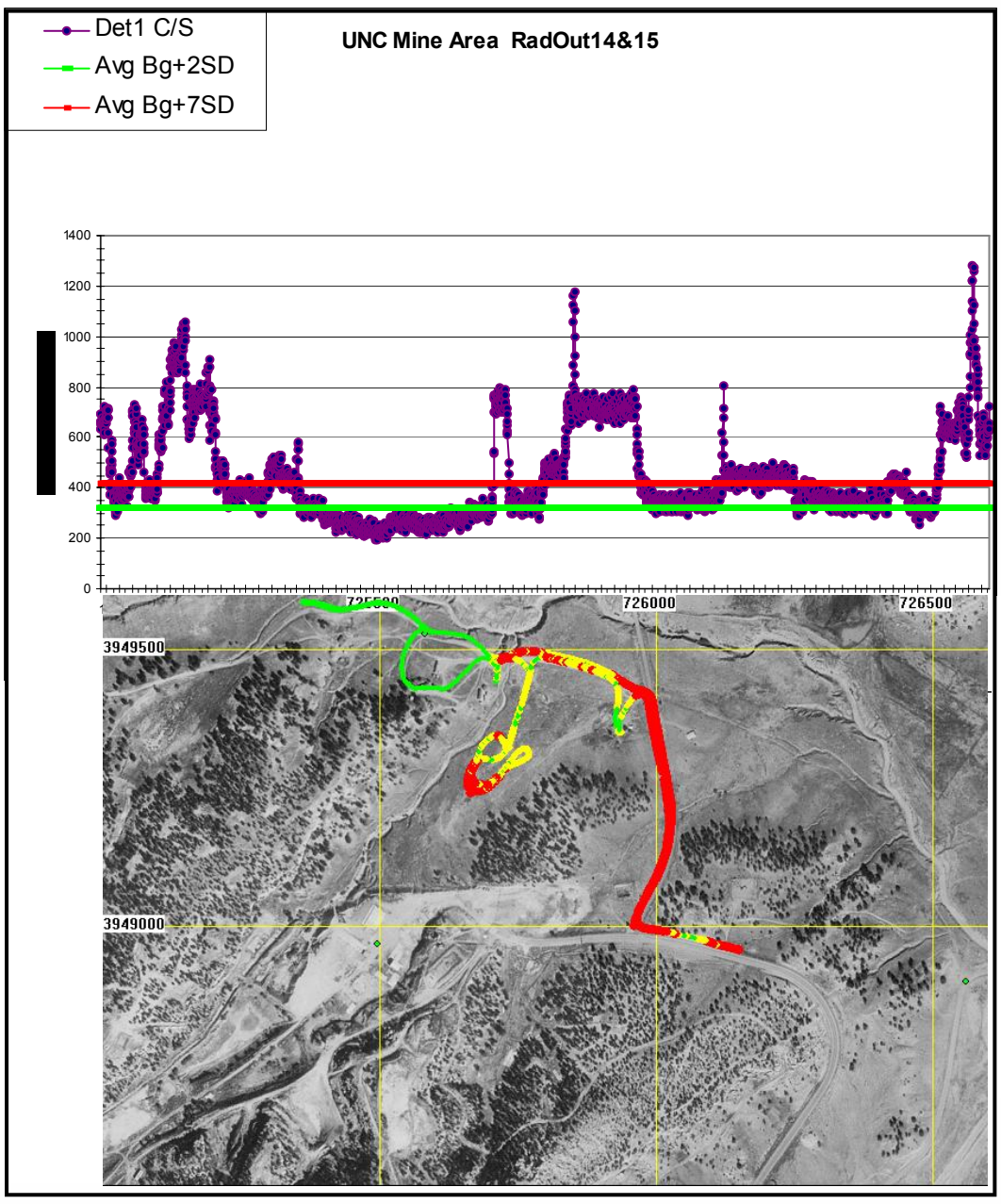


Figure 4. Truck Mounted Gamma Survey Near the United Nuclear Corporation Mine

WATER AND SEDIMENT SAMPLES

NURE HYDROGEOCHEMICAL AND STREAM SEDIMENT RECONNAISSANCE (HSSR) DATA

Systematic sampling of water and sediments over the entire United States began in 1976 under the NURE HSSR Program. Responsibility for the sampling was assigned to four DOE National Laboratories (Smith, 2006 - S06010701). Water and sediment samples on the Navajo Nation were collected by the Los Alamos National Laboratory and the Savannah River Laboratories. The results are presented on a 1° x 2° quadrangle basis. Figure 5 shows the quadrangles that cover the Navajo Nation. Some quadrangles were never completed. For example, the Marble Canyon and Flagstaff quadrangles were not sampled on Hopi Tribal Lands or much of the Navajo Nation. Originally, all samples were only analyzed for uranium. Analyses for up to 42 additional elements were authorized in 1977 and many early samples were reanalyzed. The NURE program effectively ended in 1984.

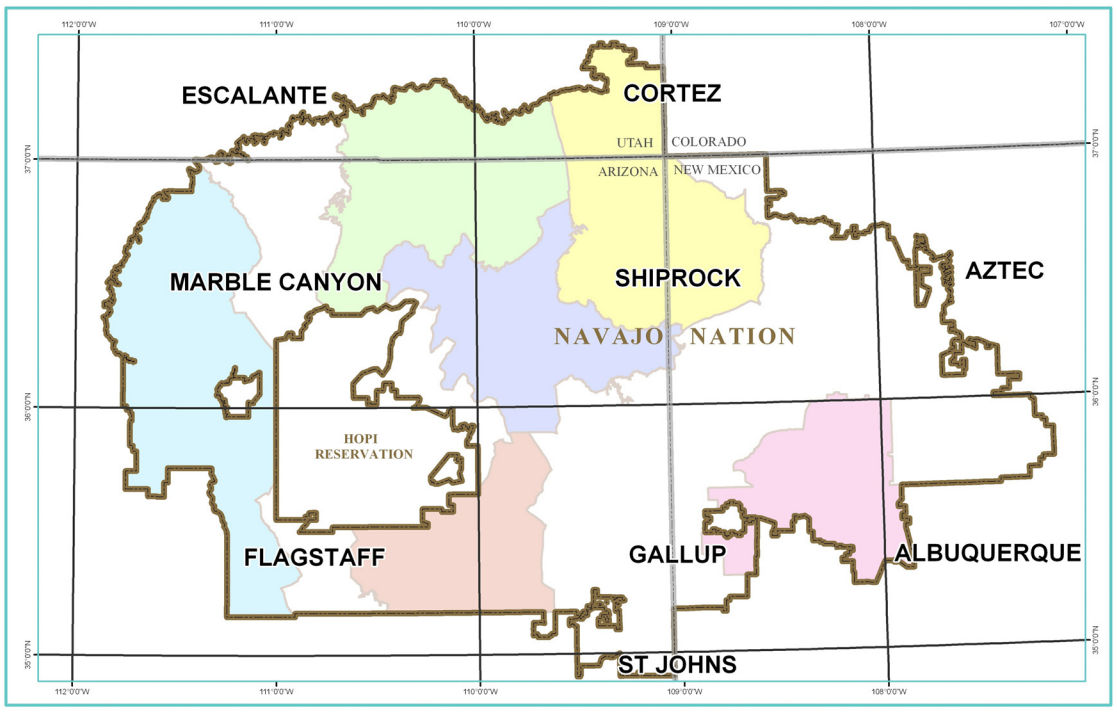


Figure 5. NURE Quadrangles Covering the Navajo Nation.

Sediment samples were collected between July 1975 and December 1979 from locations on the Navajo Nation. These data are provided as a GIS dataset on the GIS Data DVD (DB/Sampling/NN_NURE_Sediments.shp). Figure 6 below shows the distribution of the NURE sediment samples collected on the Navajo Nation. Sediment sample locations are symbolized by the source from which the sample was taken (e.g., pond, soil, spring, or stream).

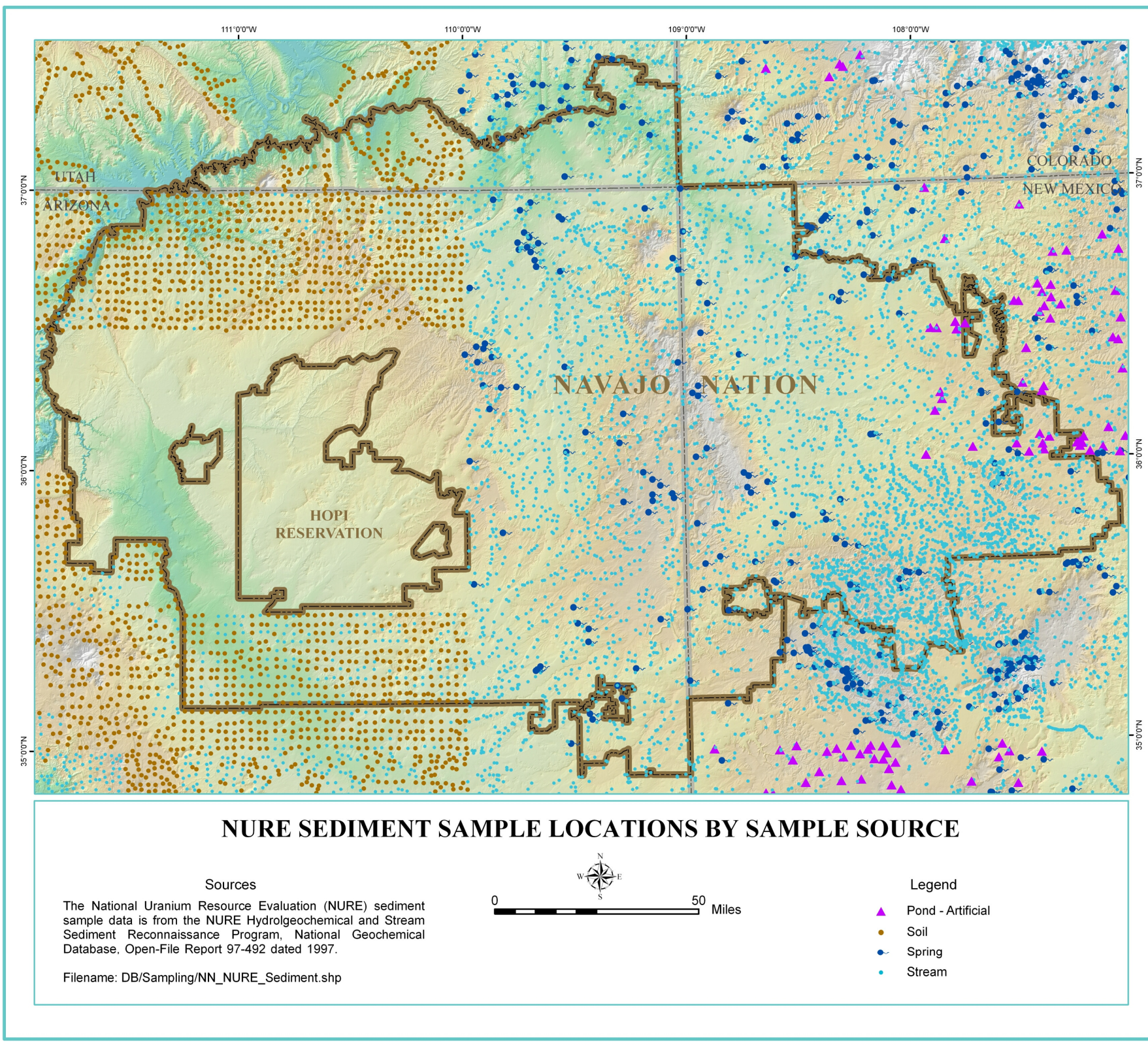


Figure 6. NURE Sediment Sample Locations by Sample Source.

WATER AND SEDIMENT SAMPLES (continued)

Water samples have been collected on the Navajo Nation for various programs and studies, and have in some cases included samples for radionuclides, including uranium. Many of these water samples were not collected from public drinking water systems and are one-time sampling events; therefore they are not definitive with respect to attribution from anthropogenic versus naturally occurring sources. Most of the samples were taken prior to NAMLRP reclamation activities and current conditions may differ. However, these radionuclide data have been included in this Atlas as data sources that may provide some useful information about where elevated levels of uranium have been found in non-public drinking water sources on the Navajo Nation. Figure 7 shows the locations of these water samples on the Navajo Nation.

NATIONAL URANIUM RESOURCE EVALUATION (NURE) WATER SAMPLES

Water samples were collected on the Navajo Nation from May 1976 through November 1979 as part of the NURE Hydrogeochemical and Stream Sediment Reconnaissance Program. Sampling was conducted in the Central and Eastern portion of the Navajo Nation, but no water samples were collected in the western 1/3 of the Navajo Nation, nor on any of the Hopi Tribal lands. 1,014 water samples were collected, with 4 from artificial ponds, 113 from springs, 33 from streams, and 864 from wells. Water samples were analyzed for uranium concentration using two methodologies: delayed neutron counting (results ranged from 0.15 ppb to 1,007.4 ppb) and fluorescence spectroscopy (results ranged from 0.01 ppb to 35.78 ppb). These data have been provided on the GIS Data DVD (DB/Sampling/NN_NURE_Water.shp).

NAVAJO ABANDONED URANIUM MINES STUDY WATER SAMPLES

In March 1998, EPA Region 9 signed an inter-agency agreement with the USACE for technical assistance on the NAUM. The USACE formed a team to investigate the effects of AUMs on the ground water. As part of the effort to assess whether uranium mining on the Navajo Nation had affected water quality, 226 locations were sampled for 23 metals and 11 radionuclides. Chapter officials selected the water sources to be sampled. Samples were taken from point of service, meaning no purging was conducted, to address the most likely exposure scenarios. Results are summarized in the NAUM Phase I Project Atlas (USEPA, 2000 - S02260102). Water sample analyses results for stable metals and radionuclide activity are provided on the GIS Data DVD (DB/Sampling/NN_USACE_Samples.shp). The water sampling performed to date is considered preliminary because it was a one-time sampling event. As a one-time sampling event, it does not take into account fluctuation in concentrations resulting from seasonal and hydrological variability. As a preliminary characterization, the primary goal was to identify areas of potential concern based on the levels of metals and radionuclides measured in the water source.

U.S. GEOLOGICAL SURVEY WATER SAMPLES

In 1991 the USGS, in cooperation with the NAMLRP, began a study to assess the chemical characteristics and hydraulic interaction of shallow ground water and mine water in AUMs in the Monument Valley and Cameron mining districts that had partially filled with water (Longsworth, 1994 - S02250302). Two (2) AUMs in the Monument Valley mining district and six (6) AUMs in the Cameron mining district were studied. Results showed that uranium-238 activities in shallow ground water from AUMs ranged from 150 to 14,000 picocuries per liter (pCi/L). Uranium-238 activities in pit water from AUMs ranged from 11 to 22 pCi/L. Radionuclide activities in well and spring water generally were less than in shallow ground water and pit water. Water from Clay Well spring, which is about 1.9 miles from the nearest AUM, had a uranium-238 activity of 27 pCi/L. Radionuclide activities in well and spring water may result from naturally occurring mineralization in water-bearing rock units. The effects of mining could not be determined from chemical analyses of well and spring water. Results from the water sampling for radionuclide activity are presented on the GIS Data DVD (DB/Sampling/USGS_Longsworth_Samples.shp)

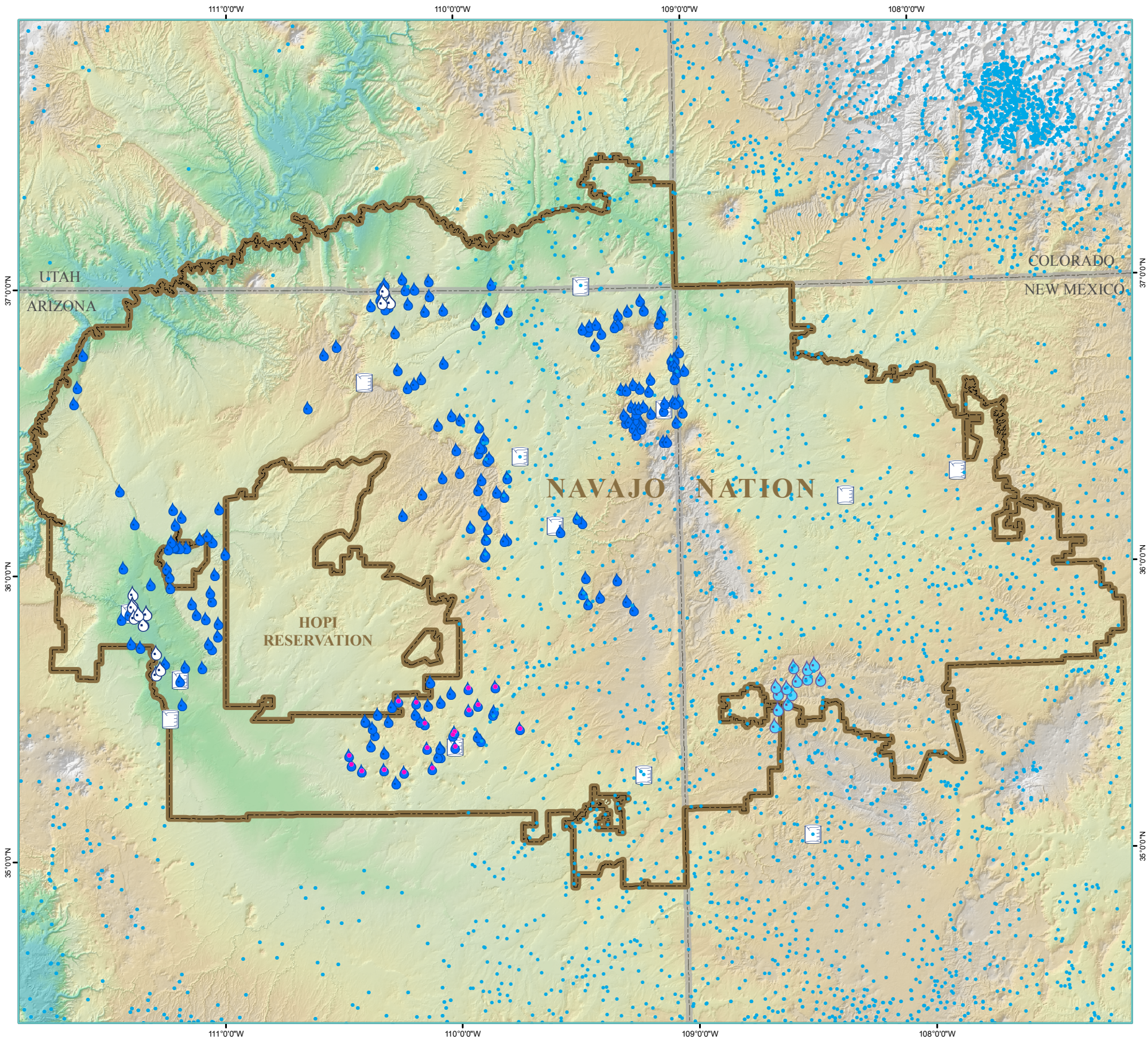
Eighteen (18) water sample locations in the Hopi Buttes area, that were previously sampled by the USACE, were resampled by George Breit and Margaret Hiza, USGS. Water samples were collected during six sampling periods (6/2001, 9/2001, 10/2001, 7/2002, 5/2003, and 6/2004). Results for 35 samples (several locations were sampled up to three times) were provided for: temperature, specific conductance, pH, aluminum; antimony, arsenic, barium, beryllium, cadmium, calcium, cobalt, chromium, copper, iron, lead, potassium, magnesium, manganese, mercury, nickel, selenium, silver, sodium, thallium, thorium, uranium, vanadium, and zinc. Uranium concentrations are reported in units of µg/L, and range from 0.02 - 17.0 µg/L. The original spreadsheet provided by George Breit is on the GIS Data DVD (DB/Sampling/USGS_Breit_Sampling_COE_5-28-07.xls), which contains notes on the methods used for the analyses. A GIS dataset was developed for the data and is provided on the GIS Data DVD (DB/Sampling/USGS_Breit_Samples.shp). No unit conversions were made to these data.

NAVAJO NATION ENVIRONMENTAL PROTECTION AGENCY WATER SAMPLES

In 2004 the Navajo Nation Surface and Ground Water Protection Department of the NNEPA conducted a study "Sanitary Assessment of Drinking Water used by Navajo Residents not Connected to Public Water Systems (Ecosystem Management, Inc., 2004 - S05150701)." Thirteen (13) unregulated water sources were sampled for radionuclides, arsenic, pesticides, and coliform after being identified as potential sources of drinking water in the selected Chapters. Three of the samples had gross alpha results that were larger than the MCL of 15 pCi/L. Results of the water sample analysis are provided on the GIS Database DVD (DB/Sampling/NNEPA_Samples.shp). A GIS dataset was developed for the data and is provided on the GIS Data DVD (DB/Sampling/NNEPA_Samples.shp).

CHURCH ROCK URANIUM MONITORING PROGRAM WATER SAMPLES

Water samples were collected in August and October 2003 by the Church Rock Uranium Monitoring Program (CRUMP) Water Assessment Team for thirteen (13) wells in the Church Rock area (CRUMP, 2003 - S01140501). Twelve (12) of the thirteen (13) wells were sampled for total uranium. Total uranium results for eleven (11) of the samples ranged from 0.04 to 9.94 pCi/L. One sample (16-4-10) had a total uranium result of 46.48 pCi/L. A GIS dataset was developed for the summary of selected radionuclides and is provided on the GIS Data DVD (DB/Sampling/CRUMP_Samples.shp).



ABANDONED URANIUM MINES AND THE NAVAJO NATION

WATER SAMPLES WITH ANALYSES FOR RADIONUCLIDES

N
W E
S

0 50 Miles

Map Scale 1:1,750,000

Sources

The National Uranium Resource Evaluation (NURE) water sample data is from the NURE Hydrogeochemical and Stream Sediment Reconnaissance Program, National Geochemical Database, Open-File Report 97-492 dated 1997.
Filename: DB/Sampling/NN_NURE_Water.shp

U.S. Geological Survey (USGS) water sample data is from the report titled "Geohydrology and Water Chemistry of Abandoned Uranium Mines and Radiochemistry of Spoil-Material Leachate, Monument Valley and Cameron Areas, Arizona and Utah," Water Resources Investigations Report 93-4226 by S.A. Longsworth dated 1994.
Filename: DB/Sampling/USGS_Longsworth_Samples.shp

U.S. Environmental Projection Agency (EPA) water sample data was collected by the U.S. Army Corps of Engineers (USACE) and is from the report titled "Abandoned Uranium Mines Project, Arizona, New Mexico, Utah - Navajo Lands 1994 - 2000, Project Atlas" dated 2000.
Filename: DB/Sampling/NN_USACE_Samples.shp

USGS water sample data was collected at 18 locations in the Hopi Buttes area that were previously sampled by the USACE. USGS collected samples during the period from June 2001 through June 2004. Data were provided by George Breit, USGS, Denver.
Filename: DB/Sampling/USGS_Breit_Samples.shp

Navajo Nation Environmental Protection Agency water sample data is from the report titled "Sanitary Assessment of Drinking Water Used by Navajo Residents Not Connected to Public Water Systems" by Ecosystem Management, Inc. dated December, 2004.
Filename: DB/Sampling/NNEPA_Samples.shp.

Church Rock Uranium Monitoring Project (CRUMP) water sample data is from a spreadsheet "CRCWellsWaterQuality2003" provided by Andrew Bain, EPA Region 9 in January, 2005.
Filename: DB/Sampling/CRUMP_Samples.shp

Legend

- National Uranium Resource Evaluation (NURE)
- U.S. Geological Survey - Longsworth
- U.S. Geological Survey - Breit
- U.S. Environmental Protection Agency
- Navajo Nation Environmental Protection Agency
- Church Rock Uranium Monitoring Project

Cameron Open Pit Mine (Field Filtering Sample)
23 July 1998, CT980723CAM004

Figure 7. Water Samples on the Navajo Nation with Analyses for Radionuclides.

AUM RECLAMATION

The NAMLRP has the authority and responsibility to reclaim uranium mines within the jurisdiction of the Navajo Nation that were left abandoned or inadequately reclaimed prior to August 3, 1977. This authority is granted under the Surface Mining Control and Reclamation Act (SMCRA) of 1977, Public Law 95-87 and the approved Navajo Reclamation Plan and Reclamation Code. The reclamation projects were designed to minimize the need for maintenance, promote landscape stability, enhance re-establishment of natural vegetation, enhance wildlife (where it is consistent with adjacent land uses), and most importantly, adequately safeguard the physical and radioactive hazards. NAMLRP is only authorized to perform reclamation activities on "tribal trust lands." A prioritization scheme for non-coal mine sites was established by the NAMLRP. Priority 1 sites exhibit extreme physical hazards, easy access, and danger to life and property. Priority 2 and 3 sites have less physical dangers, more difficult access, and lower visitation (NAMLRP, 2000 - S07220301). AUM "Problem Areas" were identified by NAMLRP, which were used for mine feature and reclamation project identifiers (Table 1). For example, "COV127" designates the 127th inventoried mine feature in the Cove Problem Area. "NA-0307" is a reclamation project in the Cove Problem Area.

Table 1. NAMLRP Problem Areas and Associated Naming Convention Designations.

PROBLEM AREA	PROJECT RANGE	MINE FEATURE		PROBLEM AREA	PROJECT RANGE	MINE FEATURE
Cameron	NA-0100	CAM		Sanostee	NA-0600	SAN
Monument Valley	NA-0200	MON		Black Mesa	NA-0700	BLK
Cove	NA-0300	COV		Bidahochi	NA-0750	BID
Beclabito	NA-0400	BEC		Oak Springs	NA-0800	OAK
Sweetwater	NA-0500	SWT		Tse Tah	NA-0900	TSE

NAMLRP conducted inventories of non-coal mine features and established priorities during the period August 1988 through October 1990 (NAMLRP, S02230324). Problem Area inventory field logs were maintained for each mine feature included in the inventory. Field observations were recorded that included parameters such as: the date of the field visit, mine feature type, description of mine feature, dimensions, drainages, evidence of visitation, impacted area estimate, spoil volume, and accessibility. Field logs are available from NAMLRP. Mine features include uranium mine portals, rimstrips, open pits, highwalls, and radioactive waste piles with low-level radioactivity. The portals and shafts are open or partially open and located on the mesa ridges/edges and flat areas. The highwalls, or mine related cliffs, are associated with portals and rimstrips. The waste piles are usually located on the flats and on steep slopes. NAMLRP inventoried over 1,000 AUM features on the Navajo Nation.

After the prioritization process, NAMLRP initiated reclamation projects. Each reclamation project started with a description of the technical specifications, including general information about the required reclamation work, mine closure methods, earthwork requirements, incidental work (e.g., mobilization, site grading to re-establish drainage patterns, access road improvement, demobilization), site specific work scope details with maps and drawings, radiological clean-up guidelines and worker safety, and cultural and fish and wildlife resources protection.

Figure 8 is an example of one of the technical specification drawings that was developed for a planned reclamation site. These drawings are available from the NAMLRP and provide valuable information about the number and type of AUM features, acreages, and estimated waste volumes. Figure 9 shows the NAMLRP Problem Areas and Priority 1, 2, or 3 AUM features. There are four (4) reclaimed AUM features in the Eastern Agency that do not have assigned priorities.

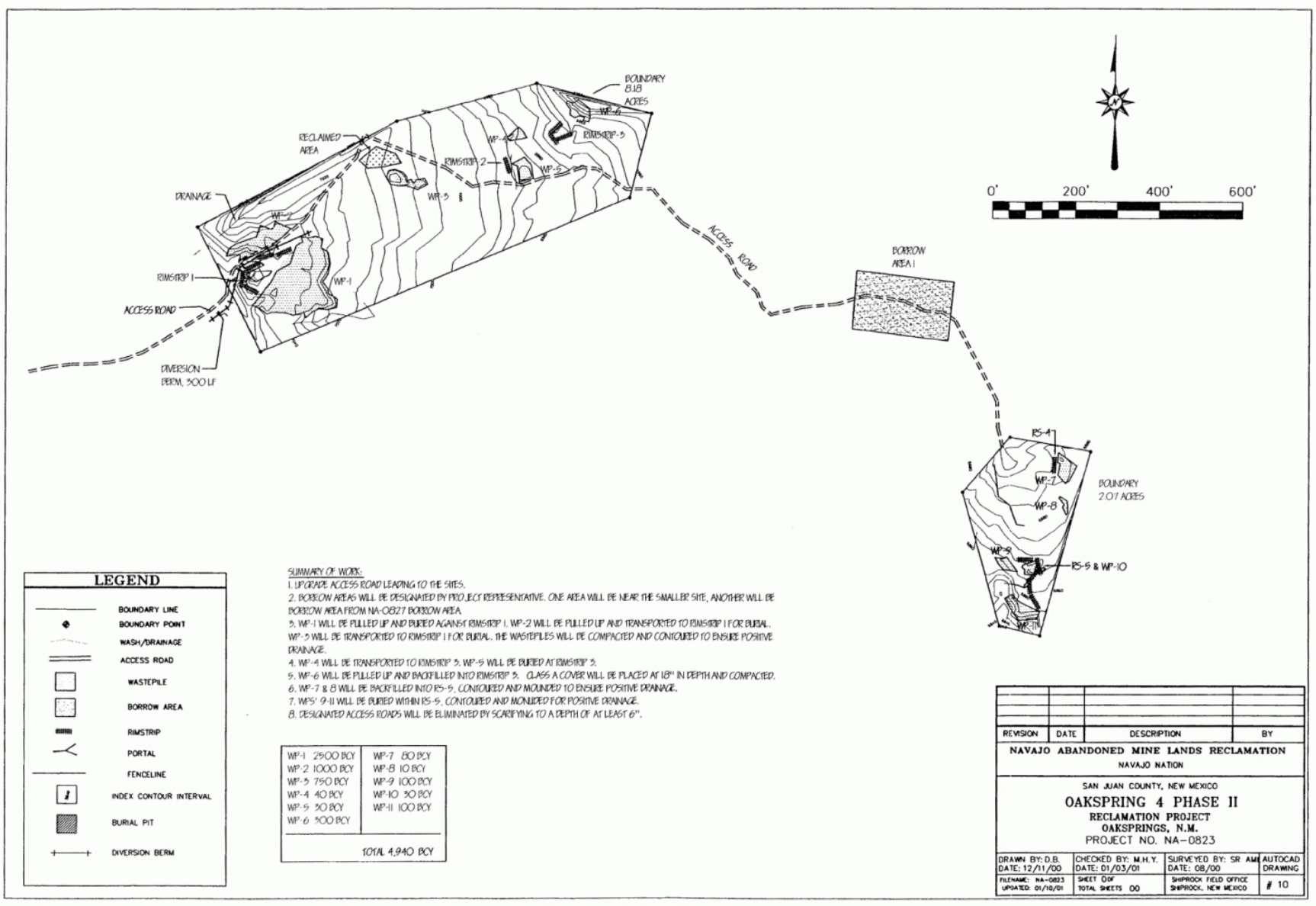
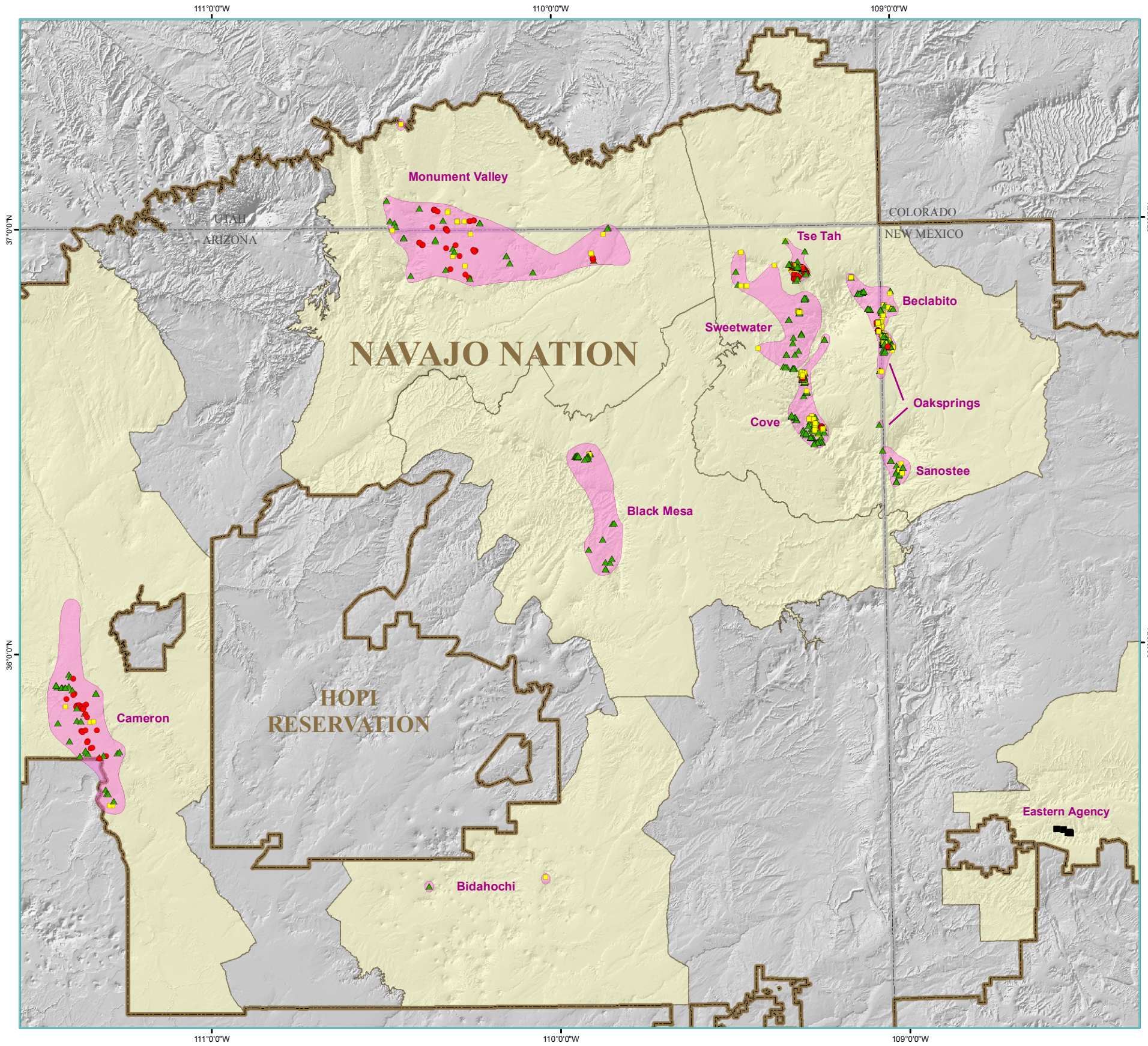
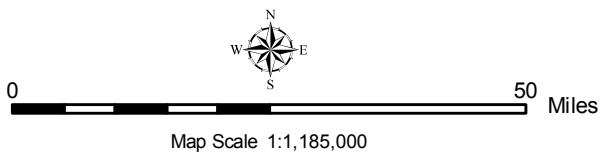


Figure 8. Example of an NAMLRP AUM Reclamation Project Site Technical Specification Drawing.



ABANDONED URANIUM MINES AND THE NAVAJO NATION

NAMLRP RECLAMATION PROBLEM AREAS WITH AUM FEATURES BY PRIORITY



Map Scale 1:1,185,000

NAMLRP reclamation site NA-0804 at Lookout Point Incline Mine. This photo shows a loader hauling Class A cover and a bulldozer placing it on a reclaimed waste pile. Photo courtesy NAMLRP.

Legend

PRIORITY
- 1 = Highest Priority
- 2 = Medium Priority
- 3 = Lowest Priority
- Unknown Priority
- NAMLRP Problem Areas
- AUM Regions

Sources

Problem area boundaries and Priority 1, 2, and 3 sites for the Navajo Nation were developed by the Navajo Abandoned Mine Lands Reclamation Program (NAMLRP). Priority 1 and 2 category sites meet criteria that concern the protection of public health and safety. Priority 3 sites meet conditions that concern environmental degradation.

Filenames:
DB/AUM/NN_AUM_Problem_Areas.shp
DB/AUM/NN_AUM_Pt_Features.shp.

Figure 9. NAMLRP Reclamation Problem Areas with Prioritized AUM Features.

AUM RECLAMATION (continued)

Site evaluation and design of reclamation projects typically involved characterization of the mine feature(s) and associated waste piles at the site. Preliminary radiometric readings were taken at mine feature locations (e.g., rimstrips, adits, pits, etc.) during the site inventories and were recorded in field logs. Prior to beginning significant reclamation activities, gamma radiation surveys were conducted. General maps were prepared for the mine site vicinity including: the mine, waste piles, protore piles, structures, and surface water drainage (NAMLRP, S05110504). Field logs and ground gamma radiation surveys are available from the NAMLRP.

During reclamation, portals and shafts were generally closed by either backfilling, by polyurethane foam (PUF) plugs, or cinderblock bulk heads (Figure 10). The rimstrips and open pits were backfilled with a combination of mine waste piles (Class B and C) and Class A cover. The waste piles were used to backfill the portals and rimstrips to a certain point, then any excess was excavated out, hauled to designated areas, placed in burial pits, and then covered with a minimum 18 inches thick compacted Class A cover (NAMLRP, 2000 - S02230328). Generally a buffer zone of clean material is placed at the bottom of the waste disposal area, then the highest levels of radioactive materials are placed on top of the buffer zone material, and the less radioactive materials are subsequently placed over them. Topsoil or non-radioactive materials (Class A) from the surrounding area are used as cover material. All radioactive waste disposal areas are located away from surface and ground water in order to prevent contamination to the local hydrology. Generally the reclaimed sites are revegetated using a suitable native seed mix (OSM, 1998 - S07220302). Work that was performed at each reclamation site included:

- Improve access roads for reclamation work
- Stabilize mine openings before closure
- Backfill or excavate any radiological “hot spots”
- Eliminate the mine feature and any related physical hazards
- Regrade all disturbed areas to ensure positive drainage around and off the reclaimed areas
- Roughen reclaimed surfaces
- Eliminate access roads at completion of reclamation.

Figure 10. Polyurethane Foam (PUF) Closure on an Open Portal. Photo courtesy NAMLRP.

Reclamation projects for all high Priority-1 and Priority-2 AUM projects have been completed. There are 166 identified unreclaimed AUM mine features with environmental problems remaining, as shown in Table 2. The environmental problems are related to uranium mine waste that remains within the AML sites. These sites are located in the high mesas and/or mountainous regions making access to these sites difficult. The NAMLRP has been recognized through OSM’s award programs for excellence in reclamation by receiving both National and regional awards (NAMLRP, 2007- S05190702).

Table 2. NAMLRP Reclamation Accomplishments by Problem Area (after NAMLRP, 2007 - S05190702)

AML PROBLEM AREAS	TOTAL # PROJECT SITES (NA-0XXX)	TOTAL # MINE FEATURES	TOTAL # RECLAIMED MINE FEATURES	# PHASES	# UNRECLAIMED MINE FEATURES	COMMENTS
Beclabito	29	90	81	4	18	OSM Award
Bidahochi	2	2	2	1	0	
Black Mesa	17	29	22	3	5	
Cameron	75	103	68	6		
Cove	58	231	202	4	84	OSM Award
Eastern Agency	3	15	14	1	4	
Monument Valley	53	82	67	4	14	OSM Award
Oak Springs	36	238	233	4	9	
Sanostee	8	19	8	1	2	
Sweetwater	27	48	42	2	13	
TseTah	37	179	178	3	17	
TOTALS	344	1036	917		166	

Figure 11 shows an enlarged portion of the Oak Springs Problem Area. The inset map shows locations of the NAMLRP Problem Areas and AUM features across the Navajo Nation. NAMLRP GIS datasets are provided on the GIS Data DVD (DB/AUM) as follows: (NN_AUM_Problem_Areas.shp); (NN_AUM_Project_Sites.shp); and (NN_AUM_Pt_Features.shp).

Figure 12 shows mine features according to reclamation status. Circles represent reclaimed mine features, squares depict unreclaimed mine features, and triangles represent locations of mine features where the reclamation status is not known. Most of these unknown features occur in the Eastern AUM Region. Red symbols indicate that there are unreclaimed waste piles nearby. Green symbols indicate AUMs that were not inventoried for the presence of unreclaimed waste piles. Blue symbols have no unreclaimed waste piles associated with the AUM.

109°3'0"W 109°2'0"W 109°1'0"W 109°0'0"W

36°44'0"N

36°43'0"N

NA-0808
NA-0800
NA-0801
NA-0818
NA-0818
NA-0802
NA-0823
NA-0823
OAK SPRINGS
NA-0827
NA-0819a
NA-0819b
63
NA-0814
NA-0803
NA-0820
NA-0813
NA-0809
NA-0805
NA-0810
NA-0822
NA-0815
NA-0824
NA-0826
NA-0806
NA-0821
NA-0807
NA-0816
NA-0811
NA-0812
NA-0817
NA-0817

109°3'0"W 109°2'0"W 109°1'0"W 109°0'0"W

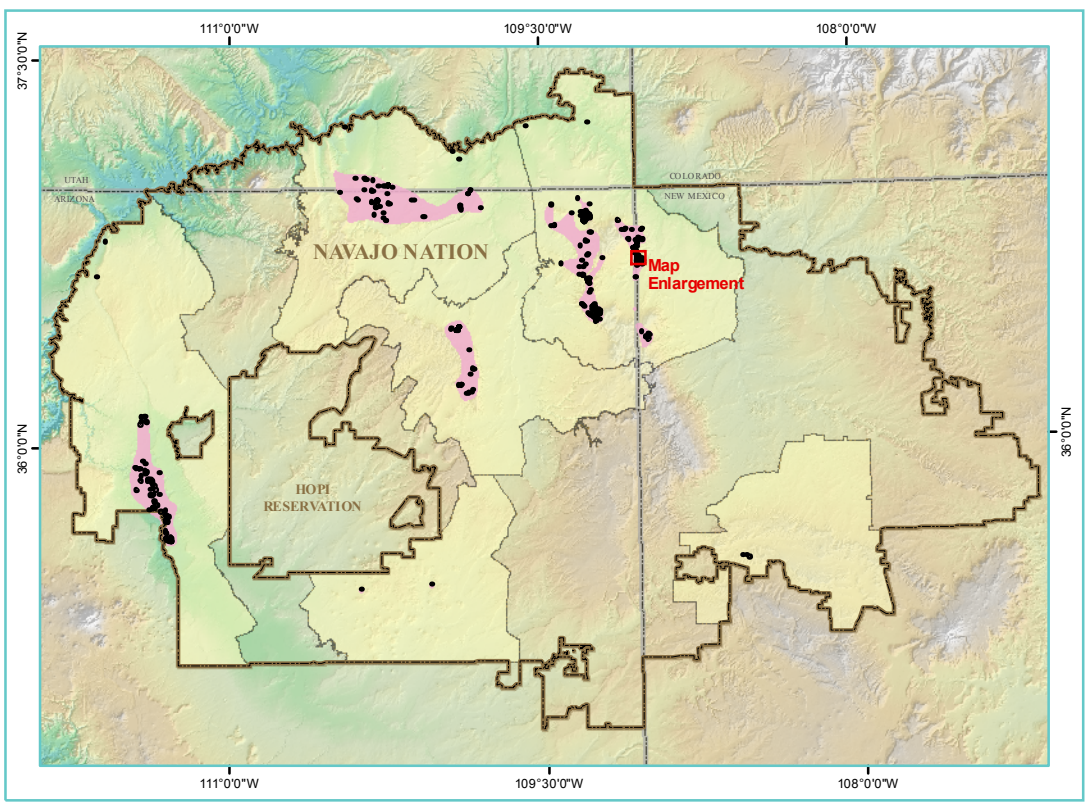
ABANDONED URANIUM MINES AND THE NAVAJO NATION

NAMLRP RECLAMATION PROJECT SITES AND AUM FEATURES IN THE OAK SPRINGS PROBLEM AREA

N W E S

0 1 Miles

Map Scale 1:24,000



Legend

AUM FEATURE

Portal

Prospect

Rimstrip / Pit

Vertical

NAMLRP Project Site

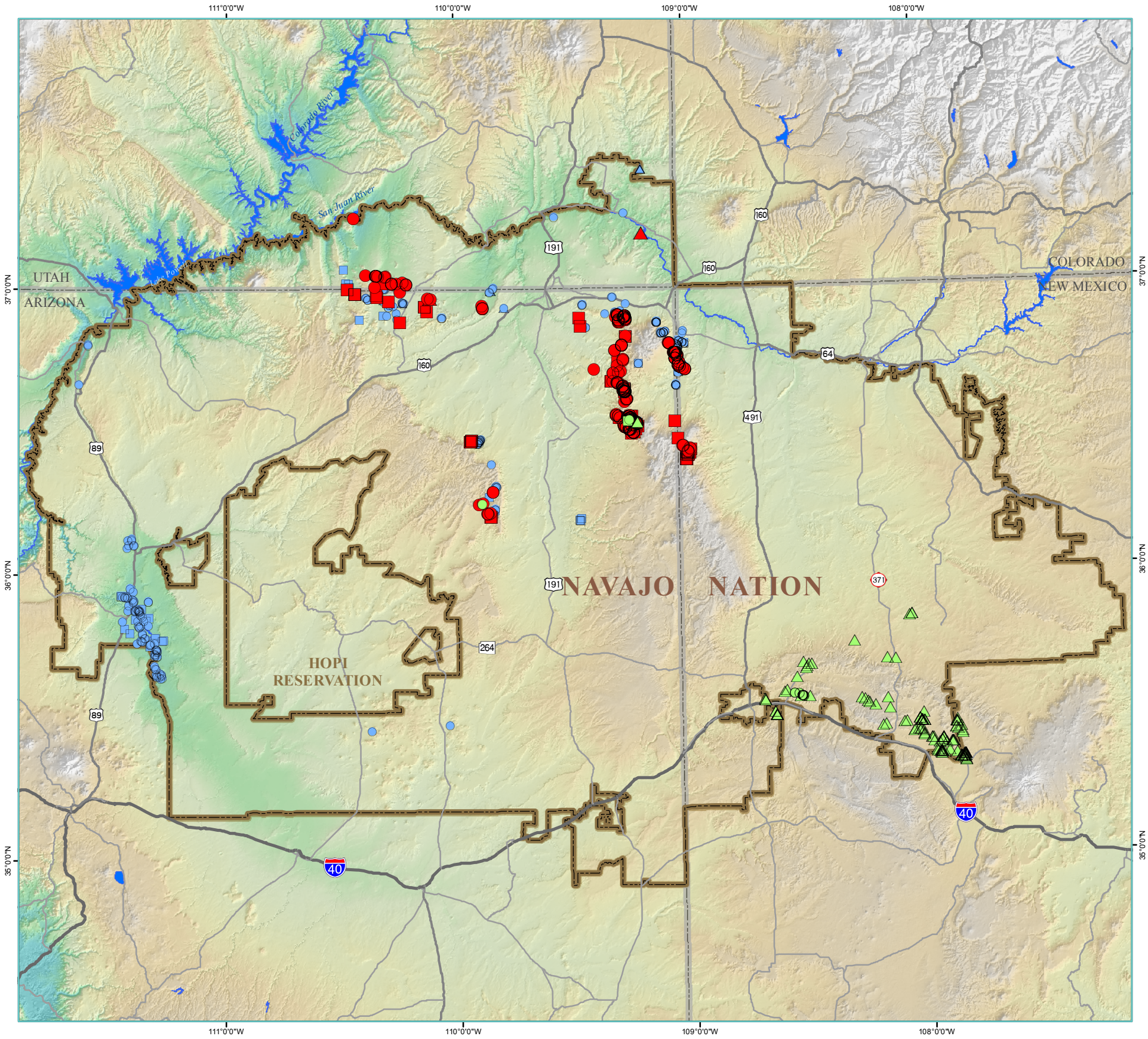
NAMLRP Problem Area

Sources

Reclamation project site boundaries and AUM feature locations are from the Navajo Abandoned Mine Lands Reclamation Program.

Filenames:
DB/AUM/NN_AUM_Problem_Areas.shp
DB/AUM/NN_AUM_Project_Sites.shp and
DB/AUM/NN_AUM_Pt_Features.shp.

Figure 11. NAMLRP Reclamation Project Sites and AUM Features in the Oak Springs Problem Area.



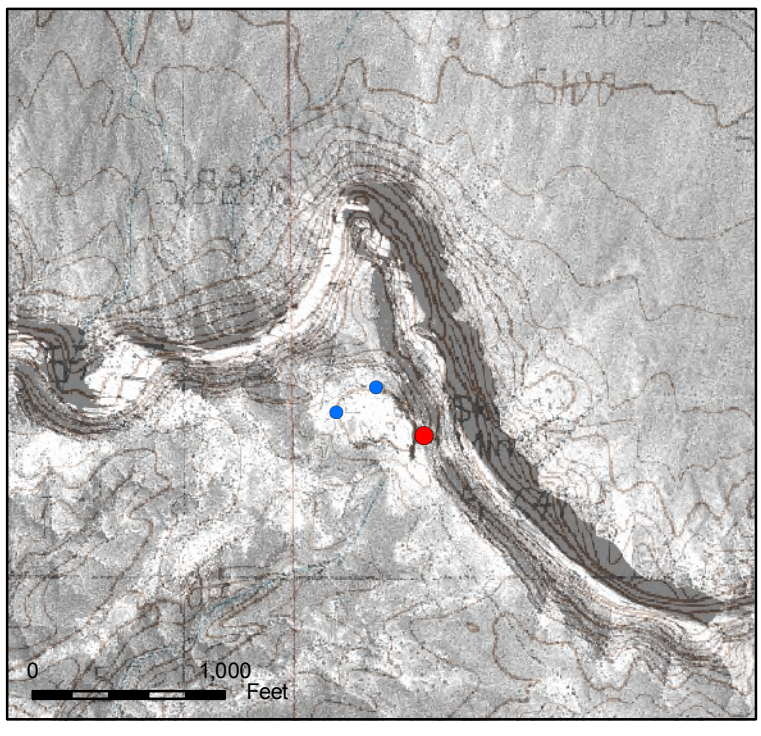
ABANDONED URANIUM MINES AND THE NAVAJO NATION

NAMLRP MINE FEATURE RECLAMATION STATUS AND UNMAPPED ASSOCIATED WASTE PILES

N
W E
S

0 50 Miles

Map Scale 1:1,750,000



The above inset shows three mine features mapped at the Skyline mine. The reclaimed mine feature (in red) is on the margin of a cliff and has an unmapped associated waste pile. The reclaimed mine features (in blue) on top of the flat mesa do not have unmapped associated waste piles.

Legend

NAMLRP MINE FEATURES

RECLAIMED FEATURE

- Unreclaimed Waste Piles Present
- Presence of Unreclaimed Waste Piles Unknown
- No Unreclaimed Waste Piles

FEATURE RECLAMATION STATUS UNKNOWN

- Unreclaimed Waste Piles Present
- Presence of Unreclaimed Waste Piles Unknown
- No Unreclaimed Waste Piles

UNRECLAIMED FEATURE

- Unreclaimed Waste Piles Present
- Presence of Unreclaimed Waste Piles Unknown
- No Unreclaimed Waste Piles

Sources

Reclamed mine feature locations and status are from the Navajo Abandoned Mine Lands Reclamation Program. The presence of waste piles was determined by NAMLRP and TerraSpectra Geomatics.

Filenames: DB/AUM/NN_AUM_Pt_Features.shp

Figure 12. NAMLRP AUM Feature Reclamation Status and Presence of Unreclaimed Waste Piles.